GEOMORPHIC CLASSIFICATION OF COASTAL LAND LOSS BETWEEN 1932 AND 1990 IN THE MISSISSIPPI RIVER DELTA PLAIN, SOUTHEASTERN LOUISIANA

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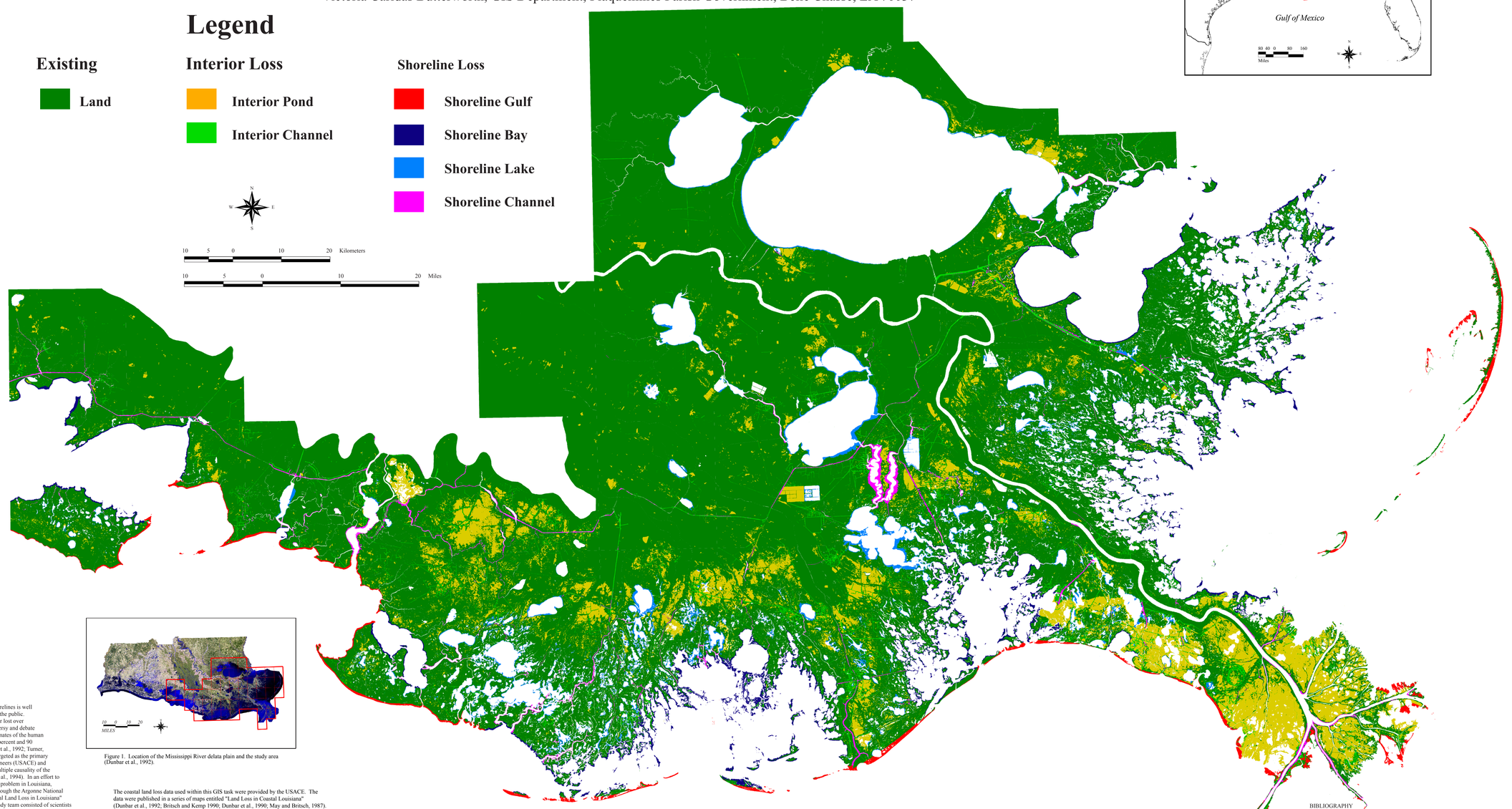

Figure 1. Location of the Mississippi River delata plain and the study area (Dunbar et al., 1992).

INTRODUCTION

The dramatic loss of Louisiana's coastal wetlands and barrier shorelines is well recognized by government agencies, industries, universities, and the public. Between 1932 and 1990, the deltaic plain of the Mississippi River lost over 680,000 acres of land due to a complex suite of causes. Controversy and debate continues as to the causes of coastal land loss in Louisiana. Estimates of the human contribution of man to the land loss problem ranges between 10 percent and 90 percent (Britsch and Kemp, 1990; Penland et al., 1990, Penland et al., 1992; Turner, 1997). Several government agencies and industries have been targeted as the primary agent of coastal land loss including the U.S. Army Corps of Engineers (USACE) and the oil and gas industry. The role of natural processes and the multiple causality of the coastal land loss problem often have been overlooked (Boesch et al., 1994). In an effort to further our understanding and knowledge of the coastal land loss problem in Louisiana, the Gas Research Institute (GRI) sponsored a research project through the Argonne National Laboratory (ANL) entitled "Natural and Human Causes of Coastal Land Loss in Louisiana" in cooperation with the U.S. Geological Survey (USGS). The study team consisted of scientists from GRI, ANL, Louisiana State University (LSU), University of New Orleans (UNO), USGS, USACE, and the Louisiana Universities Marine Consortium (LUMCON). This study focused on three major land loss research tasks:

1) Geologic Processes,
2) Vegetative Processes, and
3) Spatial Geographical Information System (GIS) Analysis.

Through these research tasks, the objectives of this study are to quantify and rank the causes of coastal land loss within the Mississippi River delta plain in southeastern Louisiana (Fig 1). This study took advantage of continuing research by the USGS in framework geology and subsidence processes, and the USACE in GIS analysis, framework geology, and subsidence processes (Dunbar et al., 1990, Dunbar et al., 1992, Britsch and Dunbar, 1993; Williams et al., 1993). The geological processes task focused on the Holocene evolution of the Mississippi River delta plain in an effort to identify the regional geological controls on coastal land loss over the last 18,000 years. The vegetative processes task conducted field investigations into the role of salt water intrusion and soil inundation in plant dieback. The GIS analysis task focused on quantifying the geomorphic forms and processes of coastal land loss using the USACE coastal land loss database. In this report, the results of the GIS geomorphic classification of coastal land loss are presented.

GEOGRAPHIC INFORMATION SYSTEMS ANALYSIS

The GIS analysis task sought to quantify the geomorphologic forms and processes of coastal land loss using new digital data. The study area for the GIS analysis is the Mississippi River delta plain in southeast Louisiana and does not include the chenier plain. The GIS analysis captures the local types and causes of coastal land loss interwoven with regional land loss processes like subsidence. Processes such as flood control, diversion control, subsidence, and eustacy generally lack spatial attributes that can be mapped and used in a GIS analysis. As a result, the GIS analysis allows the quantification of site specific processes and it does not capture the regional effects of subsidence, eustacy, and river control.

Much of the coastal land loss controversy can be attributed to a lack of spatial quantitative land loss data. Recent land loss data collection efforts undertaken by the USACE have served to address this need for information by providing maps and statistics which can be used to characterize baseline conditions of coastal land loss in Louisiana. The USGS National Coastal and Marine Geology Program supports Louisiana land loss studies which address issues such as barrier island erosion and wetland loss. Collectively, these programs provide needed resources for the development of this coastal land loss data set.

The purpose of the GIS analysis task is to expand upon baseline data collection efforts by providing quantitative information about land loss geomorphology and process. We have developed a classification scheme capable of delineating the geomorphologically distinct forms of land loss (Wayne et al., 1993).

The coastal land loss data used within this GIS task were provided by the USACE. The data were published in a series of maps entitled "Land Loss in Coastal Louisiana" (Dunbar et al., 1992; Britsch and Kemp 1990; Dunbar et al., 1990; May and Britsch, 1987). The data were provided to the classification research team in digital format and includes the following information for the Mississippi Riverdeltaic plain (Fig 1):

-1932 land/water interface base map compiled from National
Ocean Service (formerly U.S. Coast and Geodetic Survey)
topographic sheets (NOS T-sheets) and 1:62,500 USGS
topographic quadrangle maps,
-areas that converted from land to water in each of four time periods,
1932-1956, 1956/8 - 1974, 1974-1983, and 1983-1990, and
-coding which discriminates features for each time period.

The data were originally developed by the USACE to:

1) map the location of land loss in coastal Louisiana,
2) quantify the spatial and temporal magnitude of land loss between 1932 and 1990, and
3) identify significant historical trends in Louisiana land loss rates.

The mapping was accomplished by comparing 1:62,500 scale aerial photography from each study period with the coastal land loss base developed for the previous time period. Coastal land loss was defined as the conversion of land in the base map to water on the photography. NOS T-sheets served as the primary base; however, early USGS 1:62,500 topographic maps were used for those areas where T-sheet coverage was unavailable. Mapping was performed for each quadrangle map unit within the Mississippi River delta plain. Coastal land loss statistics were generated for each map then compiled to produce a loss rate curve for the entire deltaic plain (Fig 2).

Figure 2. Coastal land loss rate curve for the Mississippi River delta plain (Dunbar et al., 1992).

The USACE study of coastal land loss rates resulted in the generation of a large, detailed land loss data set. To achieve the objectives of the GIS task a single time period of data for classification was utilized. The cumulative time period (1932-1990) was selected for two primary reasons:

1) it contained the most diverse land loss conditions and therefore provided the best means of evaluating the range of applicability of the classification schemes, and
2) the interim data could be used to understand the processes af fecting the loss, and enable researchers to better refine the classification for complex loss scenarios.

The USACE coastal land loss data set was carefully reviewed to derive initial concepts of loss geomorphology and process. A mosaic of the fifty maps was created on a single wall of the laboratory and used as reference during a series of open discussions in which similarities in land loss configurations were identified and evaluated. Additional information was compiled about coastal land loss processes and landscape activities (cultural and natural) associated with individual areas of loss. This information was used to generate process scenarios for highly expressive land loss formations. Once a familiarity with the regional data set was acquired, a series of examples were extracted to illustrate rough concepts of similarity and disparity with regard to coastal land loss process and geomorphology.

These basic concepts were presented to a group of agencies, organizations, companies, and experts (Table 1). An advisory committee was created as part of the classification study comprised of scientists from the university community, state and federal government, and private business with backgrounds in sedimentology, marsh ecology, coastal geology, wildlife, biology, vegetative dynamics, and coastal management. The advisory committee provided regional and disciplinary insight, and responded to the conceptual presentation by generating a list of terms which more specifically characterized differences in form and process. The terms were organized into logical groups of process and geomorphology, and the groups were refined into initial classification schemes.

Once the initial classification schemes were derived, the advisory committee reviewed the schemes and provided critical comments. The comments were used to refine the classification schemes. Several coastal land loss committee meetings were held prior to establishing the final geomorphic and process classification schemes.

Table 1. List of agencies, companies and organizations that participated in workshops and reviews of the gis coastal land loss classification maps.

Louisiana Department of Environmental Quality	Terrebonne Parish
Louisiana Department of Natural Resources	Southern Natural Gas Company
Louisiana Department of Wildlife and Fisheries	Natural Resources Conservation Services
Louisiana Governors Office	St. Charles Parish
Louisiana Land and Exploration Company	Argonne National Laboratory
U.S. Army Corps of Engineers	Wisner Donation Advisory Committee
Louisiana State University	U. S. Fish and Wildlife Service
Southern University	National Marine Fisheries Service
Louisiana Universities Marine Consortium	Tulane Environmental Law Clinic
Coalition to Restore Coastal Louisiana	Louisiana Sea Grant College Program
Shell Offshore	Gulf Restoration Network
T. Baker Smith and Son, Inc.	Amoco
Texaco Exploration and Production Inc.	Times-Picayune
Environmental Protection Agency	Morning Advocate
Barataria-Terrebonne National Estuary Program	Exxon Company
Southern Lafourche Levee District	New Orleans City Planning Commission
Lafourche Parish	Southeastern University
BP Oil Company	Lake Pontchartrain Basin Foundation
Sierra Club Defense Fund	Women for a Better Louisiana
Coastal Environments Inc.	Loyola University
U.S. Geological Survey	Gas Research Institute
William W. Goodell Jr. P.L.C.	Bayou Lafourche Fresh Water District
Applied Technology Research Corporation	Louisiana Mid-Continent Oil and Gas Association
Jefferson Parish	University of New Orleans

GEOMORPHIC CLASSIFICATION

The geomorphic classification is intended to capture information about the physical form of coastal land loss areas. Development of the geomorphic classification scheme was based upon two fundamental observations: 1) areas of land loss are, by definition, water, and 2) morphology can not imply action or process. As a result, the derived scheme employs morphological parameters commonly associated with the description of water-bodies while avoiding process-oriented qualifiers. For example, the term *erosional shadow* aptly describes the linear loss patterns that occur in the lee of a coastal engineering structure. However, the term also imparts specific information about the process that may have caused the land loss and therefore is not appropriate for the geomorphic classification.

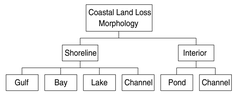

Figure 3. Structure of the geomorphic land loss classification of the Mississippi River delta plain.

There are two loss types to the geomorphic classification hierarchy as illustrated in Figure 3. The first loss type, called shoreline, applies to loss areas that occur relative to existing waterbodies. The second type, called interior, applies to loss areas that occur independent of existing waterbodies. Shoreline loss areas are typically curvalinear, mirror the morphology of the previous shoreline, and have a large ratio of shoreline length to total area. Interior loss areas are new waterbodies that develop within the land mass and may vary in form from linear to rounded. Interior areas may also occur adjacent to existing waterbodies, but the ratio of shoreline length to total area is smaller than that of shoreline areas.

The next level of the hierarchy addresses the waterbody type most closely related to loss. For shoreline areas, this level depicts the type of waterbody physically related to the loss. Four types of shoreline loss were established:

1) gulf- the outer shoreline facing the Gulf of Mexico,
2) bay- semi-enclosed waterbody with direct contact to the Gulf of Mexico,
3) lake- enclosed or semi-enclosed waterbody with no direct contact to the Gulf of Mexico
4) channel- linear waterbody that commonly connects other waterbodies.

For interior areas, this level of the classification depicts the waterbody type that is most similar to new interior loss. Two interior classes were established:

1) pond- enclosed or semi-enclosed waterbody with minor connections to the existing drainage network, and
2) channel- narrow , linear waterbody.

GEOMORPHOLOGIC CLASSIFICATION RESULTS

The results of the coastal land loss geomorphgic classification are presented in Table 2. Table 2 lists the coastal land loss geomorphology statistics for the entire delta plain quadrangle set. Between 1932 and 1990, over 690,915 acres of land were converted to water. Of this total, 482,988 acres, or 69.91%, of loss was attributed to interior loss and 207,927 acres or 30.09% was attributed to shoreline loss. For the interior loss class, interior ponding accounted for 57.05% followed by interior channels at 12.86%. For shoreline loss, the bay class at 10.67% was followed by the lake class at 9.48%, the gulf class at 5.161%, and the channel class at 4.78%.

Table 2. The geomorphic coastal land loss statistics for the Mississippi River delta plain.

CLASS NAMES	ACREAGE	PERCENT
INTERIOR LOSS		
Interior Ponding	394,164	57.05%
Interior Channel	88,824	12.86%
Subtotal	482,988	69.91%
SHORELINE LOSS		
Shoreline Gulf	35,644	5.16%
Shoreline Bay	73,736	10.67%
Shoreline Lake	65,487	9.48%
Shoreline Channel	33,060	4.78%
Subtotal	207,927	30.09%
TOTAL	690,915	100.00%

The geomorphic land loss classification describes the form or type of loss. The interior classification is by far the greatest form or type of loss at 69.91%. The formation of interior ponds ranks the highest of the interior class at 57.05%. The shoreline class ranks second at 30.09%. Shoreline loss along lakes (9.48%) and bays (10.67%) are the highest ranked types or forms.

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